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(51) INT CL<sup>5</sup>

F16H 55/14 55/08

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F2Q Q7H1 Q7H4B Q7H4C Q7H5C

(56) Documents Cited

GB 1584391 A GB 1202806 A US 4437356 A

US 4140026 A

(58) Field of Search

UK CL (Edition M ) F2Q

INT CL<sup>5</sup> F16H

(54) Gear elements having resilient teeth

(57) A gear element 100 having resilient teeth is provided to reduce backlash and tooth noise, the resiliency being provided by a series of slots 101 extending inwardly from the base region between adjacent teeth. The slots may be filled with a resilient material (201 Fig 2 not shown). The gear element may take the form of a spur or pinion gear, a rack gear (Fig 3), an internal ring gear (Fig 4), a roller worm gear (Fig 5), a bevel gear (Fig 6), a worm wheel (Fig 7), or be one of a pair of inter-fitting coupling elements (Figs 8 and 9).

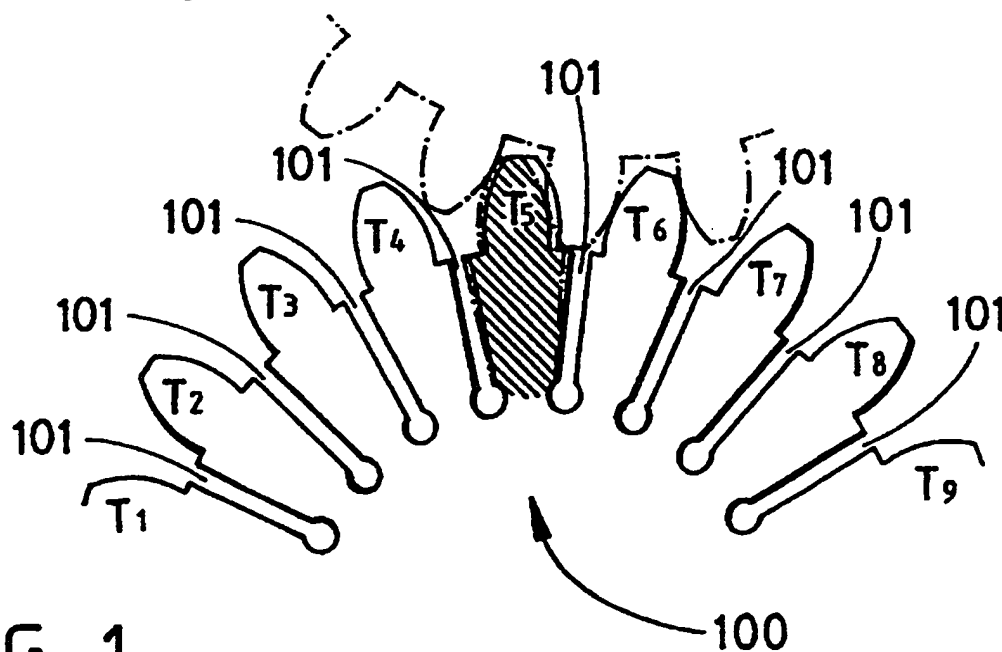


FIG. 1

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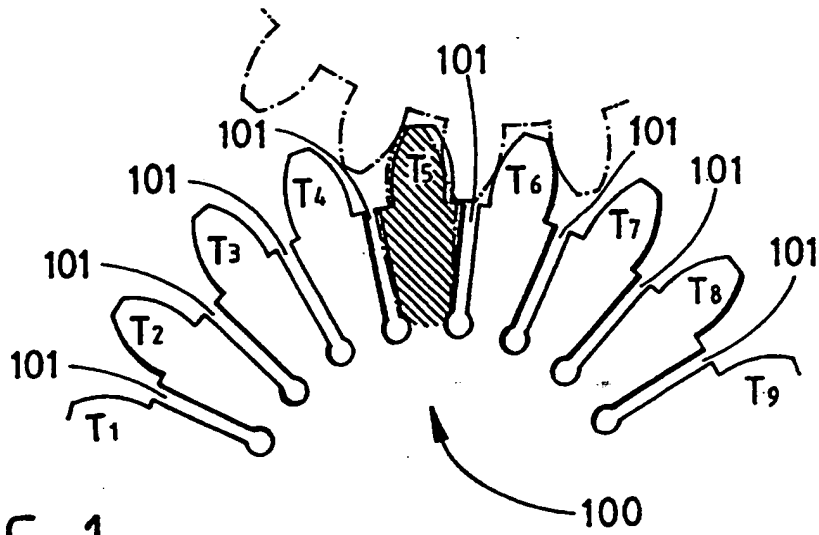


FIG. 1

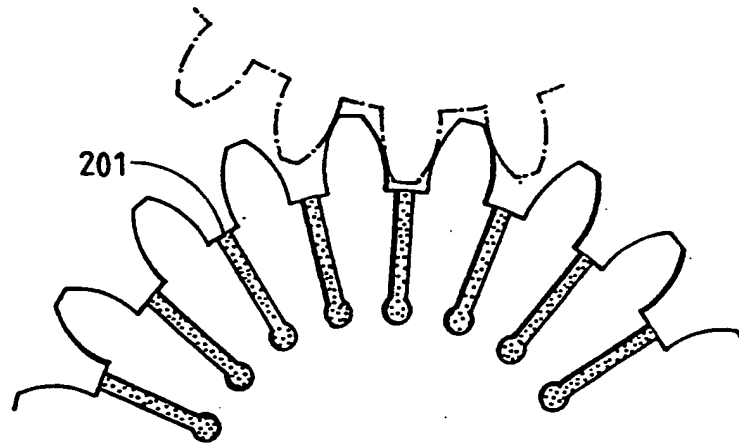


FIG. 2

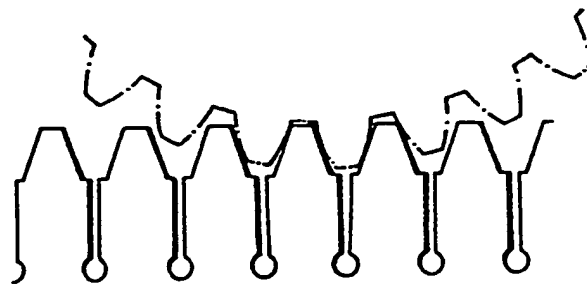


FIG. 3

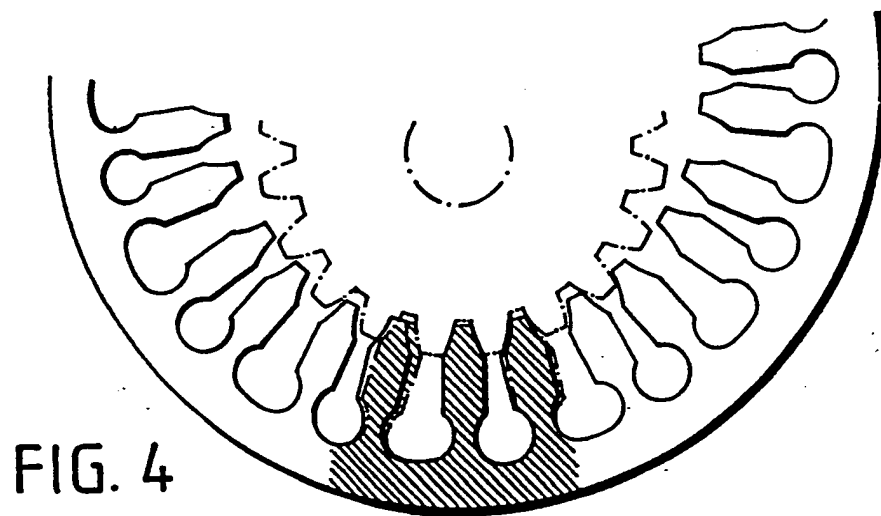


FIG. 4

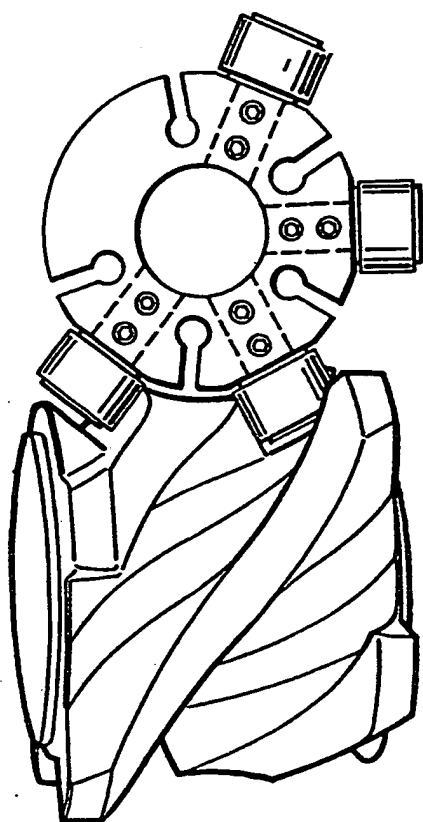


FIG. 5

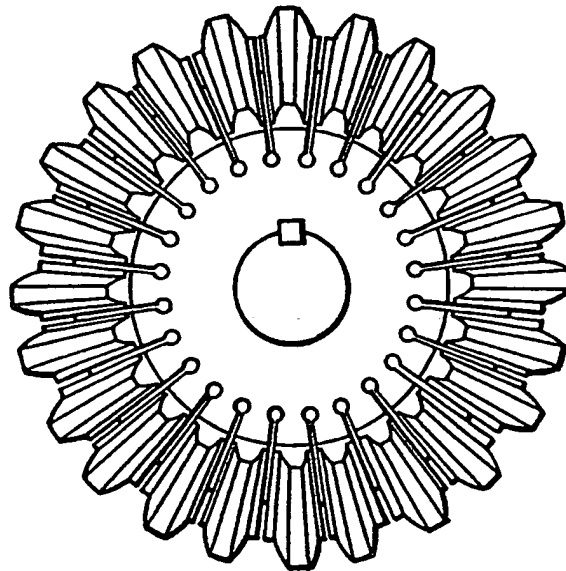


FIG. 6

FIG. 7

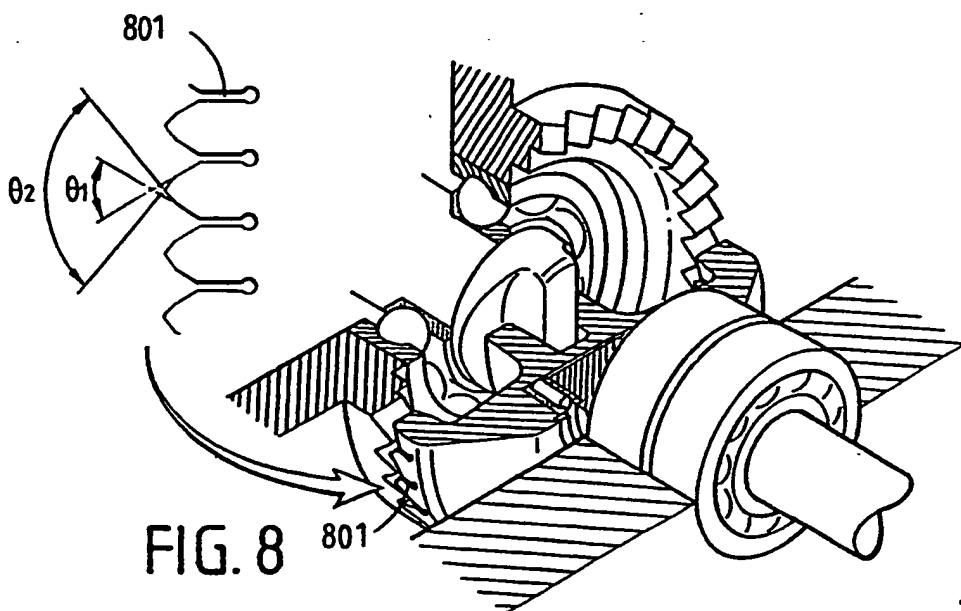
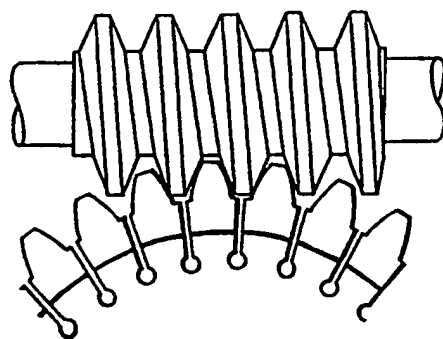
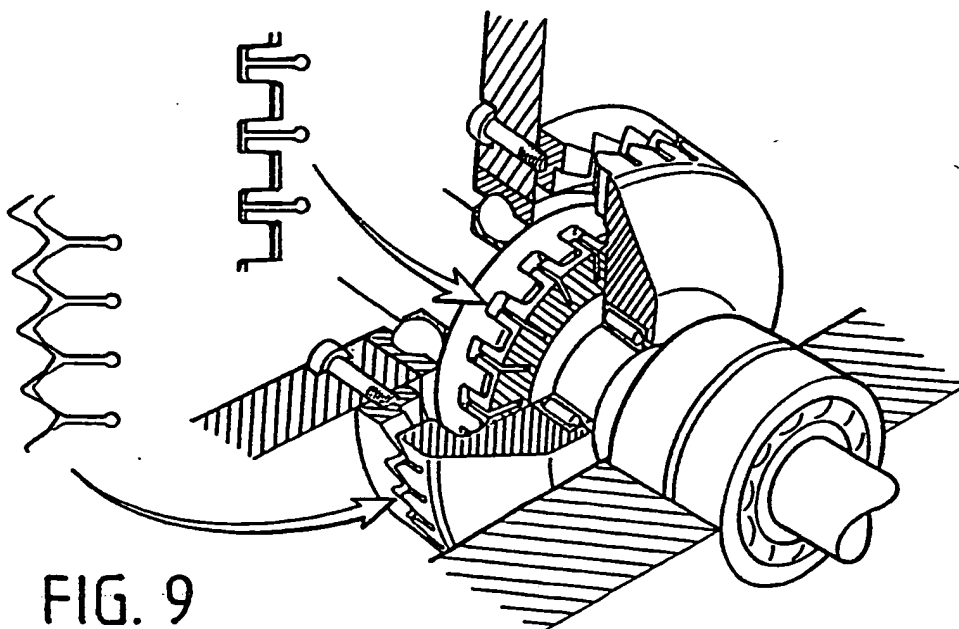


FIG. 9



## TITLE

Flexible Back Lash Eliminating Design And  
Structure.

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## SUMMARY OF THE INVENTION

The conventional gear root often relates to rigid structure so that practical gear system must be added auxiliary structure but related back lash and noise still remain as a headache. The present flexible back  
10 lash eliminating design and structure is thus made in order to solve the aforesaid problem. more specifically transformation lash is made between roots of gear to enable each pitch to appear cross difference value. After made into gear set  
15 engagement, it will form a distribution greater than back lash and with bilateral cross flexible prestress for eliminating back lash during gearing; or further filling flexible stuff within transformation lash to minimize frictional noise. Because of gear roots with  
20 flexibility, the present invention is therefore suitable for medium-small power transfer while larger power may be obtained from increased tooth thickness or multiple gear sets arrangement.

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## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagramatic view showing two gear sets to appear equi-pitch cross distribution and appear unequivalent phase difference distribution and with flexible gear root.

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FIG. 2 is an embodiment showing shock-absorbing

soft metal or plastic flexible material is filled in the lash of transformation root of gear of FIG. 1.

FIG. 3 is an embodiment showing the present flexible back lash eliminating design and structure is applied to rack gear set.

FIG. 4 is an embodiment showing the present flexible back lash eliminating design and structure applied to internal gear set.

FIG. 5 is an embodiment showing the present flexible back lash eliminating design and structure applied to roller type worm gear set.

FIG. 6 is an embodiment showing the present flexible back lash eliminating design and structure applied to bevel gear set.

FIG. 7 is an embodiment showing the present flexible back lash eliminating design and structure applied to worm gear set.

FIG. 8 is an embodiment showing the present flexible back lash eliminating design and structure applied to axial harmonic gear.

FIG. 9 is an embodiment showing the present flexible back lash design and structure applied to axial harmonic gear set with toothes coupler.

## DETAILED DESCRIPTION OF THE INVENTION

The present design relates to flexible back lash eliminating design and structure that form a distribution greater than back lash and with bilateral cross flexible prestress for eliminating back lash during gearing so as to minimize frictional

noise during gearing. which is characterized by:

two gear sets with equi-pitch cross distribution  
and unequivalent phase difference distribution, at  
least one gear set having flexible-root gear sets  
5 gearing, with distribution greater than back lash and  
with flexible tension.

The aforesaid structural principle is described  
below:

FIG. 1 is a diagrammatic view showing two gear sets  
10 to appear equi-pitch cross distribution and appear  
unequivalent phase difference distribution and with  
flexible gear root, comprising gear set 100  
peripherally distributed with odd numbers of teeth  
T1, T3, T5, T7....., even numbers of teeth T2, T4, T6,  
15 T8..... wherein pitch between each two odd teeth is  
2P, each two even teeth is also 2P; pitch between  
each two odd teeth and even tooth as well as each two  
even teeth and odd teeth is unequivalent; both sides  
of each tooth root have transformation lash 101 cut  
20 in toward the center of circle to enable each tooth  
root with flexibility; upon engaging gear sets. the  
aforesaid specific pitch and flexible tooth root  
enables engaging teeth between gear sets to appear  
different-direction flexible back-lash free for the  
25 aforesaid odd-even teeth engaging and teeth engaging  
between two different gear sets whereby back lash is  
eliminate and frictional noise reduced during  
gearing.

FIG. 2 is an embodiment showing flexible material  
30 201 is filled in the lash of transformation root of

gear teeth mainly for preventing noise caused by vibration during quick return of transformation teeth relatively disengaging.

Based on the principle shown in FIG. 1, we may  
5 apply it to right gear, bevel gear, rack gear set, worm gear set, internal gear, external gear, planet gear, harmonic gear, roller gear or toothed clutch.

FIG. 3 is an embodiment showing the present flexible back lash eliminating design and structure  
10 is applied to rack gear set, comprising:

1. connection of gear having flexible teeth and odd-even unequal phase difference with rigid rack;
2. connection of rigid odd-even unequal difference gear with flexible equi-pitch rack;
- 15 3. connection of flexible gear with rack of odd-even unequal phase difference.

FIG. 4 is an embodiment showing the present flexible back lash eliminating design and structure applied to internal gear set.

20 FIG. 5 is an embodiment showing the present flexible back lash eliminating design and structure applied to roller type worm gear set.

FIG. 6 is an embodiment showing the present flexible back lash eliminating design and structure  
25 applied to bevel gear set.

FIG. 7 is an embodiment showing the present flexible back lash eliminating design and structure applied to worm gear set.

FIG. 8 is an embodiment showing the present  
30 flexible back lash eliminating design and structure



applied to harmonic gear, wherein harmonic gear has produced differential displacement depending on different number of teeth between swinging bevel drive gear with driven gear because when the present  
5 flexible back lash eliminating design and structure is applied to swinging press-fit gears, not only with aforesaid transformation lash  $\theta_1$  at the tooth root but also with stuff, and further with relative press-fit by means of pre-tension after fitted or  
10 spring or fluid for packing two gears, and relative press-fit teeth in normal form but further greater angle  $\theta_2$  than tooth-form angle  $\theta_1$ , i.e.  $\theta_2 > \theta_1$  to compensate flexible transformed angle displacement during driving so as to guide relatively press-fit  
15 teeth point to avoid mutual interference.

FIG. 9 is an embodiment showing the present flexible back lash design and structure applied to harmonic gear set with tooth coupler wherein harmonic gear except with swinging bevel drive gear and driven  
20 gear as shown in FIG. 8, for producing differential displacement due to difference in the number of teeth between both, and differential displacement output is provided for rotary power transmission by means of teeth point with synco toothed coupler for guiding  
25 obtuse angle.

Except transformation lash between teeth, there is transformation lash between the teeth of synco toothed coupler, and toothed point is made in form of inverted obtuse angle or inverted arc against  
30 original tooth form, and packing pre-tension existing

after teeth engagement or spring pre-tension or fluid pre-tension available for eliminating back lash, and further filled in shock-absorbing soft metal or plastic flexible material to reduce noise. Referring to FIGs. 8 and 9, teeth relationship between gear set and synco clutch is arranged as odd-even unequal pitch, and further may appear equi-angle distribution while teeth point cut with guide-in bevel obtuse angle, and using spring or fluid as pre-tension packing for eliminating back lash after two teeth engagement; the aforesaid flexible back lash eliminating design and structure synco coupling clutch may be independently applied to other mechanism.

The present flexible back lash eliminating design and structure assembly may include:

1. Drive side with flexible and odd-even unequal pitch phase-difference drive gear engaging with rigid equal-pitch driven gear set at driven side;
2. Drive side with rigid and odd-even unequal pitch phase-difference drive gear engaging with flexible equal-pitch driven gear set;
3. Drive side with rigid and odd-even equal-pitch engaging with rigid odd-even unequal phase-difference driven gear set;
4. Drive side with rigid and odd-even equal-pitch engaging with flexible odd-even unequal phase-difference driven gear set.
5. Both drive and driven sides with flexible odd-even unequal-pitch gear sets.

Referring to the applications in FIG. 1 thru FIG.  
9, flexible lash of various gear sets may further be  
filled soft metal or plastic material as stuff for  
absorbing noise, and such stuff may include which for  
5 flexible lash of equal-pitch gears.

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CLAIMS:

1. A flexible back lash eliminating design and structure relates to transformation lash is made between roots of gear to enable each pitch to appear  
5 cross difference value, after made into gear set engagement, it will form a distribution greater than back lash and with bilateral cross flexible prestress for eliminating back lash during gearing; or further filling flexible stuff within transformation lash to  
10 minimize frictional noise, comprising gear set 100 peripherally distributed with odd numbers of teeth T1, T3, T5, T7....., even numbers of teeth T2, T4, T6, T8..... wherein pitch between each two odd teeth is 2P, each two even teeth is also 2P; pitch between  
15 each two odd teeth and even tooth as well as each two even teeth and odd teeth is unequivalent; both sides of each tooth root have transformation lash 101 cut in toward the center of circle to enable each tooth root with flexibility; upon engaging gear sets. the  
20 aforesaid specific pitch and flexible tooth root enables engaging teeth between gear sets to appear different-direction flexible back-lash free for the aforesaid odd-even teeth engaging and teeth engaging between two different gear sets whereby back lash is  
25 eliminate and frictional noise reduced during gearing.

2. The flexible back lash eliminating design and structure according to claim 1, including application  
30 to right gear, bevel gear, rack gear set, worm gear

set, internal gear, external gear, planet gear,  
harmonic gear, roller gear or toothed clutch,  
including:

1. Drive side with flexible and odd-even unequal  
5 pitch phase-difference drive gear engaging with rigid  
equal-pitch driven gear set at driven side;
2. Drive side with rigid and odd-even unequal pitch  
phase-difference drive gear engaging with flexible  
equal-pitch driven gear set;
- 10 3. Drive side with rigid and odd-even equal-pitch  
engaging with rigid odd-even unequal phase-difference  
driven gear set;
4. Drive side with rigid and odd-even equal-pitch  
engaging with flexible odd-even unequal  
15 phase-difference driven gear set.
5. Both drive and driven sides with flexible odd-even  
unequal-pitch gear sets.

3. The flexible back lash eliminating design and  
20 structure according to claim 1, which is applied to  
rack gear set, comprising:

1. connection of gear having flexible teeth and  
odd-even unequal phase difference with rigid rack;
2. connection of rigid odd-even unequal difference  
25 gear with flexible equi-pitch rack;
3. connection of flexible gear with rack of odd-even  
unequal phase difference.

4. The flexible back lash eliminating design and  
30 structure according to claim 1, which is applied to

harmonic gear. wherein harmonic gear has produced differential displacement depending on different number of teeth between swinging bevel drive gear with driven gear because when the present flexible back lash eliminating design and structure is applied to swinging press-fit gears, not only with aforesaid transformation lash 801 at the tooth root but also with stuff, and further with relative press-fit by means of pre-tension after fitted or spring or fluid for packing two gears, and relative press-fit teeth in normal form but further greater angle 02 than tooth-form angle 01, i.e.  $02 > 01$  to compensate flexible transformed angle displacement during driving so as to guide relatively press-fit teeth point to avoid mutual interference.

5. The flexible back lash eliminating design and structure according to claim 1, which is applied to harmonic gear set with tooth coupler wherein harmonic gear except with swinging bevel drive gear and driven gear for producing differential displacement due to difference in the number of teeth between both, and differential displacement output is provided for rotary power transmission by means of teeth point with synco toothed coupler for guiding obtuse angle, except transformation lash between teeth, there is transformation lash between the teeth of synco toothed coupler, and toothed point is made in form of inverted obtuse angle or inverted arc against original tooth form, and packing pre-tension existing

after teeth engagement or spring pre-tension or fluid pre-tension available for eliminating back lash.

5 6. The flexible back lash eliminating design and structure according to claim 1, teeth relationship between gear set and synco clutch is arranged as odd-even unequal pitch, and further may appear equi-angle distribution while teeth point cut with guide-in bevel obtuse angle, and using spring or  
10 fluid as pre-tension packing for eliminating back lash after two teeth engagement.

7. The flexible back lash eliminating design and structure according to claim 1 or 2 or 3 or 4 or 5 or  
15 6, flexible lash of various gear sets may further be filled soft metal or plastic material as stuff for absorbing noise, and such stuff may include which for flexible lash of equal-pitch gears.

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**Relevant Technical Fields**

- (i) UK Cl (Ed.M) F2Q  
(ii) Int Cl (Ed.5) F16H

Search Examiner  
A HABBIJAM

Date of completion of Search  
30 MARCH 1994

**Databases (see below)**

(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

Documents considered relevant following a search in respect of Claims :-  
1-7

(ii)

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Y: Document indicating lack of inventive step if combined with one or more other documents of the same category. E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.  
A: Document indicating technological background and/or state of the art. &: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 1584391	(MIKIHARU IMAZAIKE) see in particular Figures 4 and 5	1, 2
X	GB 1202806	(GEMCO ELECTRIC CO) see in particular Figures 2, 3 and 6	1, 2
X	US 4437356	(MIKIHARU IMAZAIKE) see clearances 6 between teeth 2, 3; Figures 1-4	1, 2
X	US 4140026	(ROUVEROL) see gashes 17 in Figure 1	1, 2

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